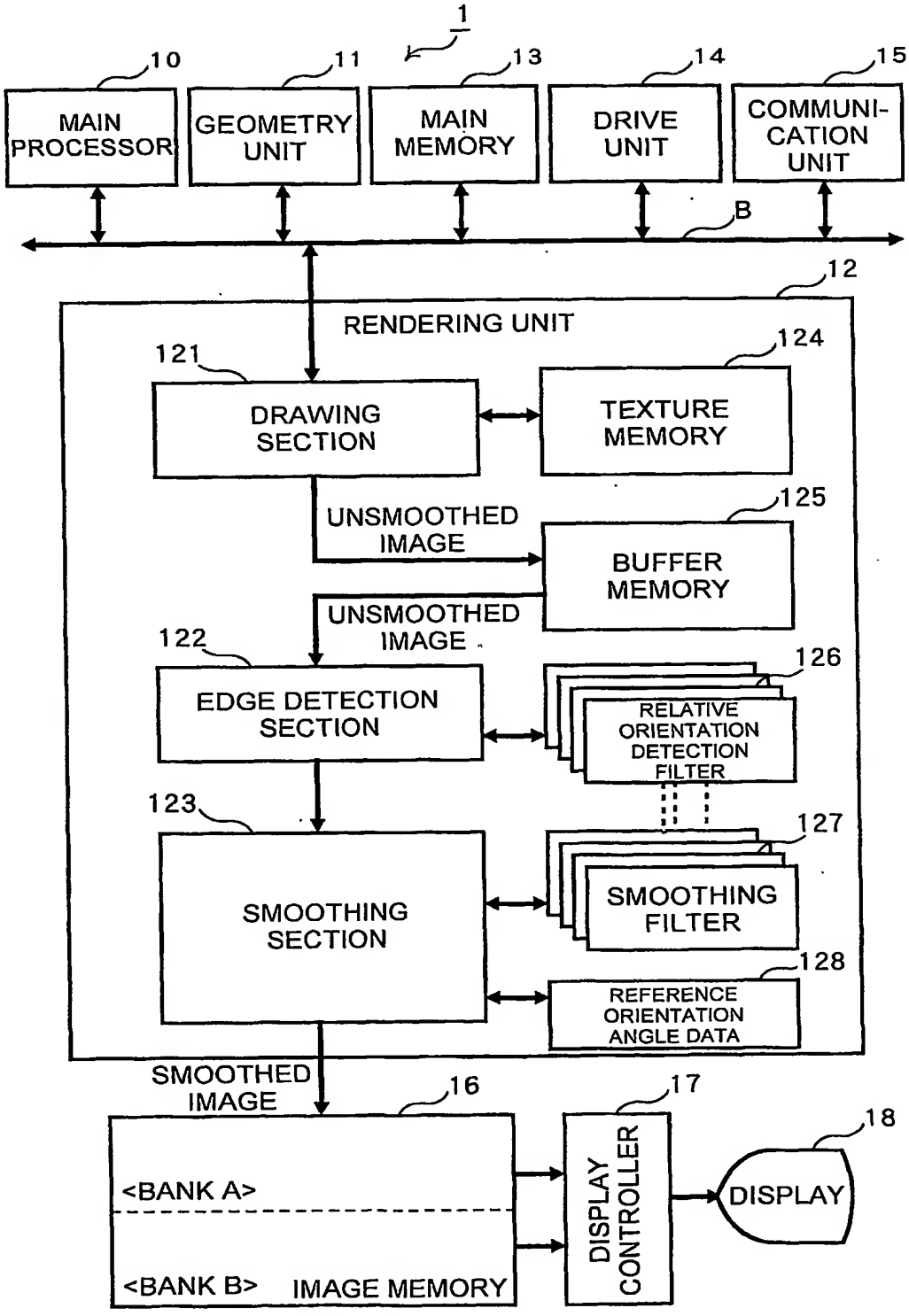

1
10
11
13
14
15
MAIN PROCESSOR
GEOMETRY UNIT
MAIN MEMORY
DRIVE UNIT
COMMUNI-CATION UNIT
B
12
RENDERING UNIT
121
DRAWING SECTION
124
TEXTURE MEMORY
UNSMOOTHED IMAGE
125
BUFFER MEMORY
UNSMOOTHED IMAGE
122
EDGE DETECTION SECTION
126
RELATIVE ORIENTATION DETECTION FILTER
123
SMOOTHING SECTION
127
SMOOTHING FILTER
128
REFERENCE ORIENTATION ANGLE DATA
SMOOTHED IMAGE
16
17
18
<BANK A>
<BANK B>
IMAGE MEMORY
DISPLAY CONTROLLER
DISPLAY

FIG. 1

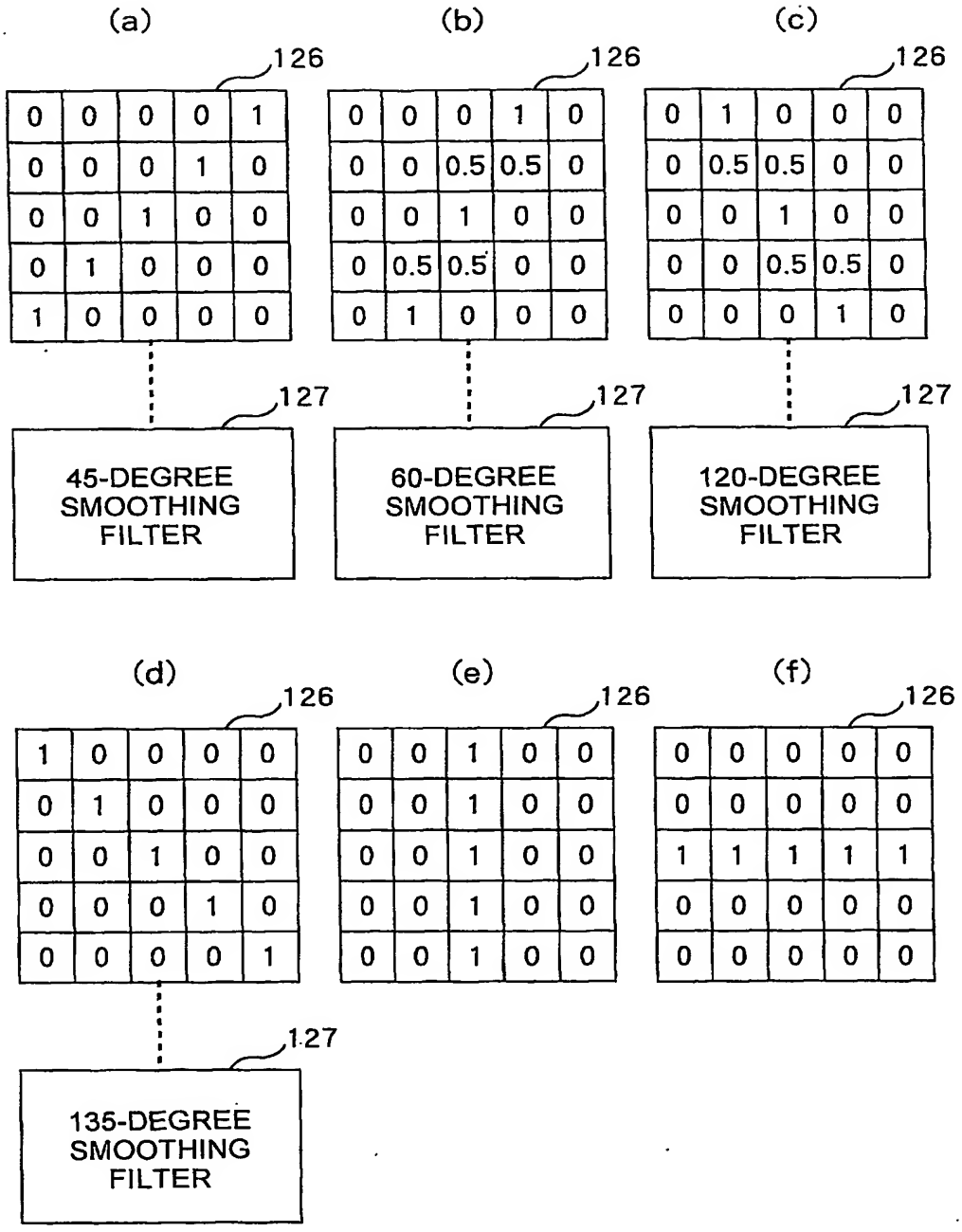
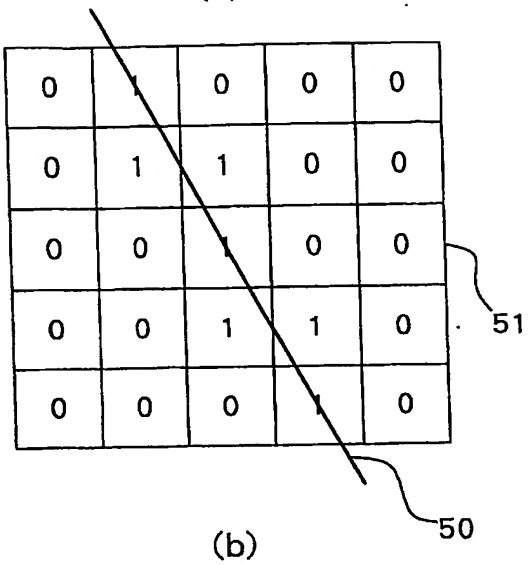
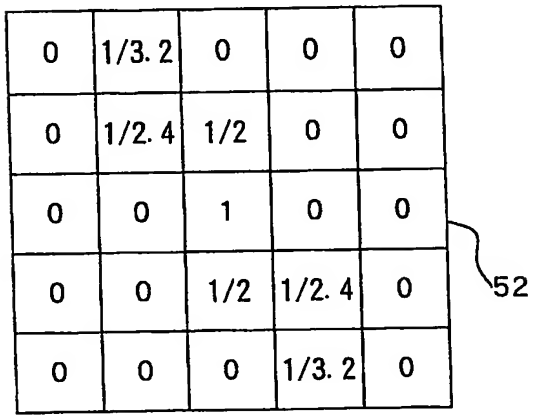

(a)
126
0 0 0 0 1
0 0 0 1 0
0 0 1 0 0
0 1 0 0 0
1 0 0 0 0
127
45-DEGREE SMOOTHING FILTER
(b)
126
0 0 0 1 0
0 0 0.5 0.5 0
0 0 1 0 0
0 0.5 0.5 0 0
0 1 0 0 0
127
60-DEGREE SMOOTHING FILTER
(c)
126
0 1 0 0 0
0 0.5 0.5 0 0
0 0 1 0 0
0 0 0.5 0.5 0
0 0 0 1 0
127
120-DEGREE SMOOTHING FILTER
(d)
126
1 0 0 0 0
0 1 0 0 0
0 0 1 0 0
0 0 0 1 0
0 0 0 0 1
127
135-DEGREE SMOOTHING FILTER
(e)
126
0 0 1 0 0
0 0 1 0 0
0 0 1 0 0
0 0 1 0 0
0 0 1 0 0
(f)
126
0 0 0 0 0
0 0 0 0 0
1 1 1 1 1
0 0 0 0 0
0 0 0 0 0

FIG. 2

(a)


0 1 0 0 0
0 1 1 0 0
0 0 1 0 0
0 0 1 1 0
0 0 0 1 0
51
50

(b)


0 1/3.2 0 0 0
0 1/2.4 1/2 0 0
0 0 1 0 0
0 0 1/2 1/2.4 0
0 0 0 1/3.2 0
52

(c)

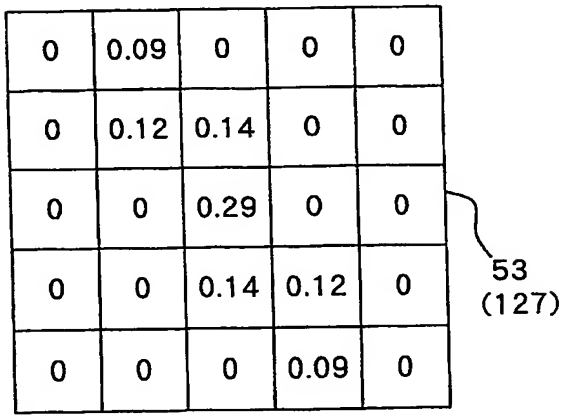

0 0.09 0 0 0
0 0.12 0.14 0 0
0 0 0.29 0 0
0 0 0.14 0.12 0
0 0 0 0.09 0
53
(127)

FIG. 3

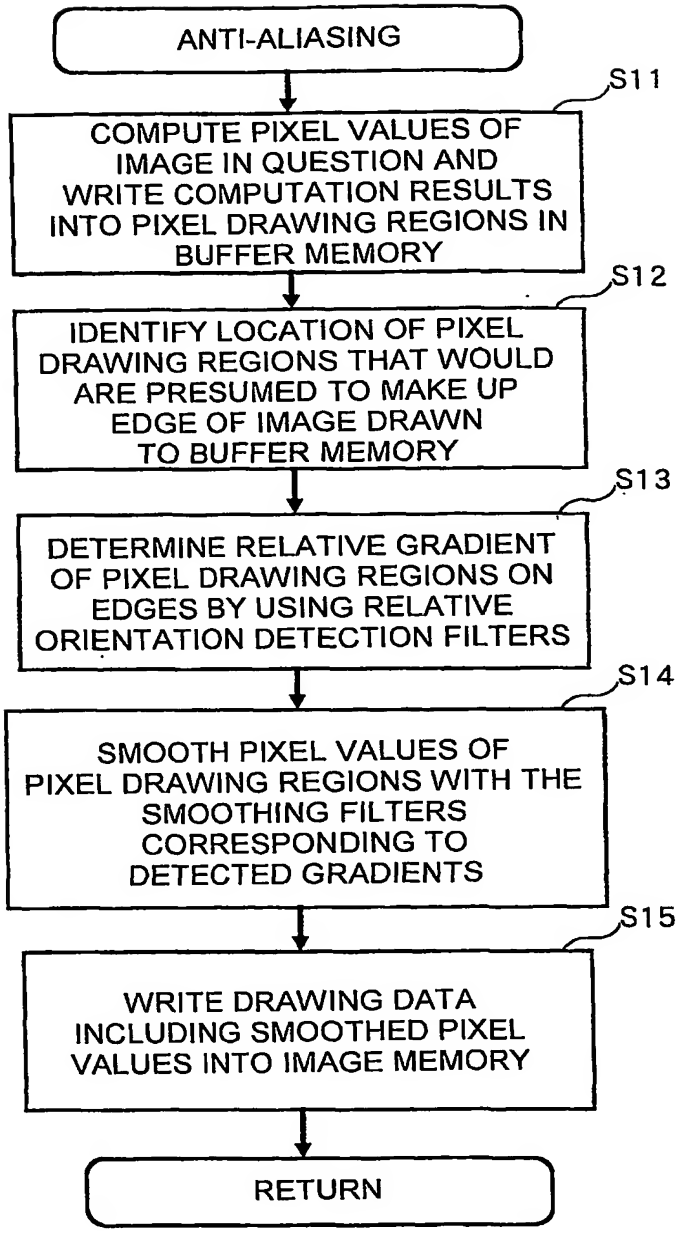

ANTI-ALIASING
S11
COMPUTE PIXEL VALUES OF IMAGE IN QUESTION AND WRITE COMPUTATION RESULTS INTO PIXEL DRAWING REGIONS IN BUFFER MEMORY
S12
IDENTIFY LOCATION OF PIXEL DRAWING REGIONS THAT WOULD ARE PRESUMED TO MAKE UP EDGE OF IMAGE DRAWN TO BUFFER MEMORY
S13
DETERMINE RELATIVE GRADIENT OF PIXEL DRAWING REGIONS ON EDGES BY USING RELATIVE ORIENTATION DETECTION FILTERS
S14
SMOOTH PIXEL VALUES OF PIXEL DRAWING REGIONS WITH THE SMOOTHING FILTERS CORRESPONDING TO DETECTED GRADIENTS
S15
WRITE DRAWING DATA INCLUDING SMOOTHED PIXEL VALUES INTO IMAGE MEMORY
RETURN

FIG. 4

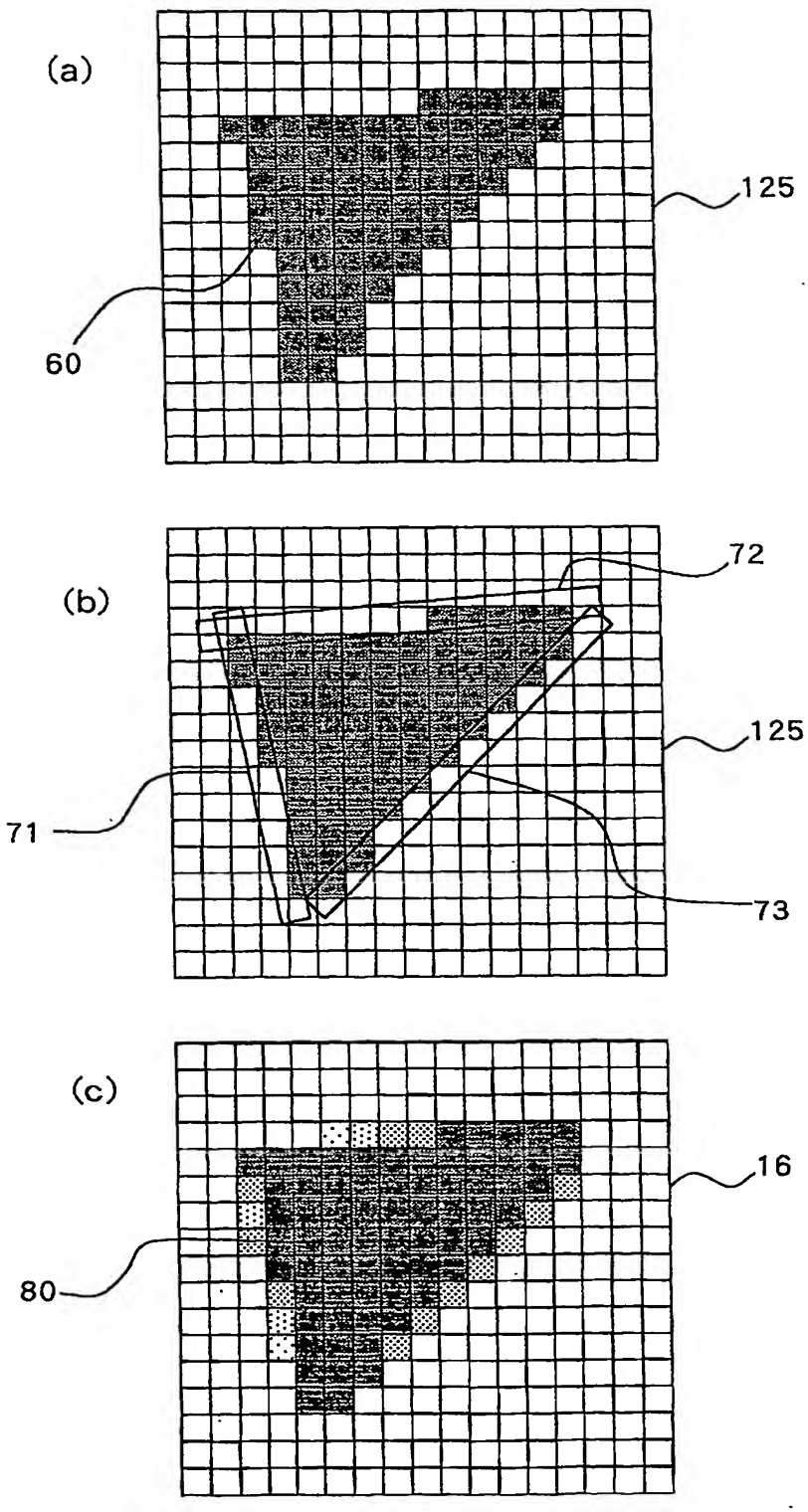


FIG. 5

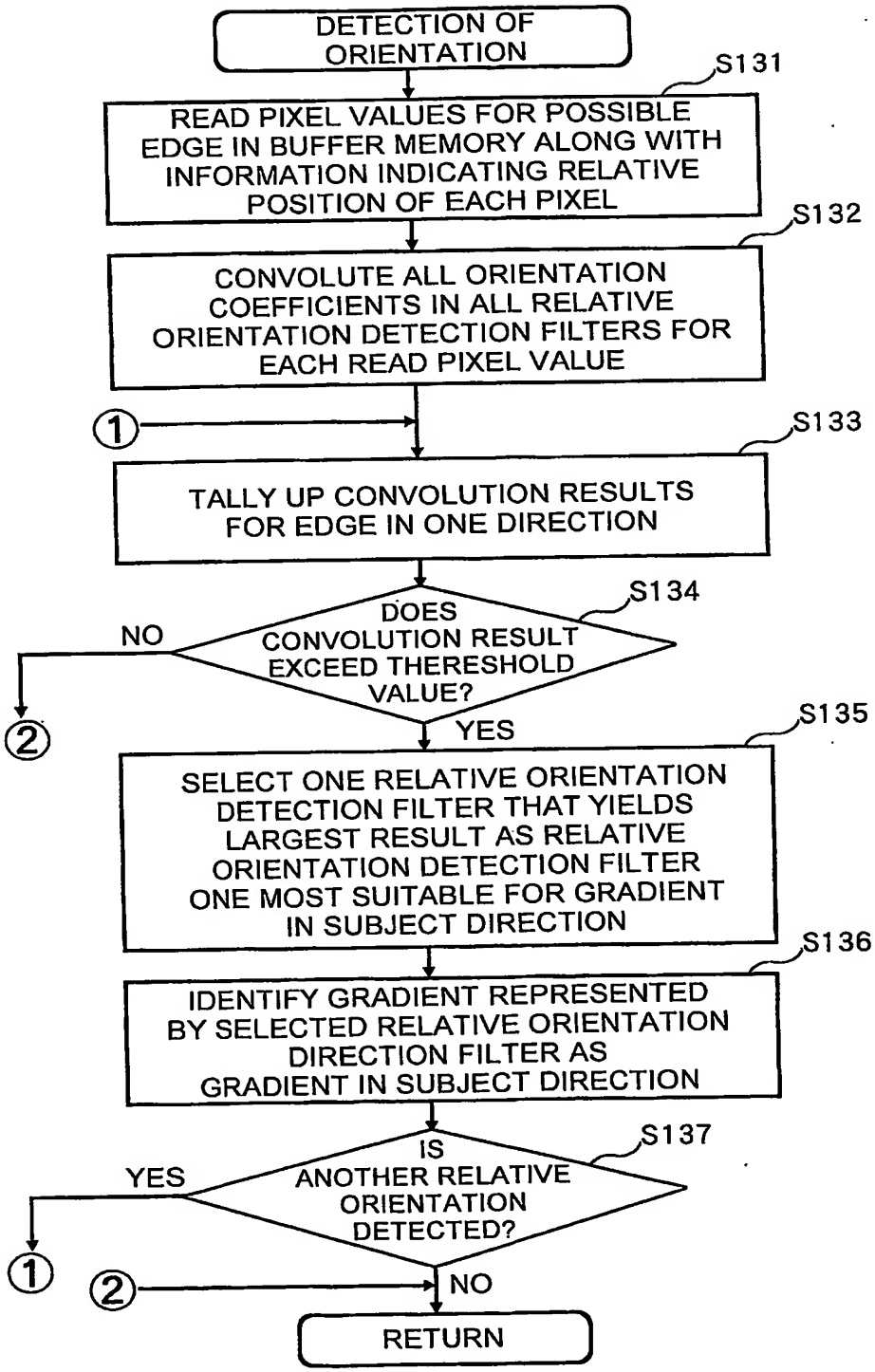

DETECTION OF ORIENTATION
S131
READ PIXEL VALUES FOR POSSIBLE EDGE IN BUFFER MEMORY ALONG WITH INFORMATION INDICATING RELATIVE POSITION OF EACH PIXEL
S132
CONVOLUTE ALL ORIENTATION COEFFICIENTS IN ALL RELATIVE ORIENTATION DETECTION FILTERS FOR EACH READ PIXEL VALUE
①
S133
TALLY UP CONVOLUTION RESULTS FOR EDGE IN ONE DIRECTION
S134
DOES CONVOLUTION RESULT EXCEED THERESHOLD VALUE?
NO
②
YES
S135
SELECT ONE RELATIVE ORIENTATION DETECTION FILTER THAT YIELDS LARGEST RESULT AS RELATIVE ORIENTATION DETECTION FILTER ONE MOST SUITABLE FOR GRADIENT IN SUBJECT DIRECTION
S136
IDENTIFY GRADIENT REPRESENTED BY SELECTED RELATIVE ORIENTATION DIRECTION FILTER AS GRADIENT IN SUBJECT DIRECTION
S137
IS ANOTHER RELATIVE ORIENTATION DETECTED?
YES
①
②
NO
RETURN

FIG. 6

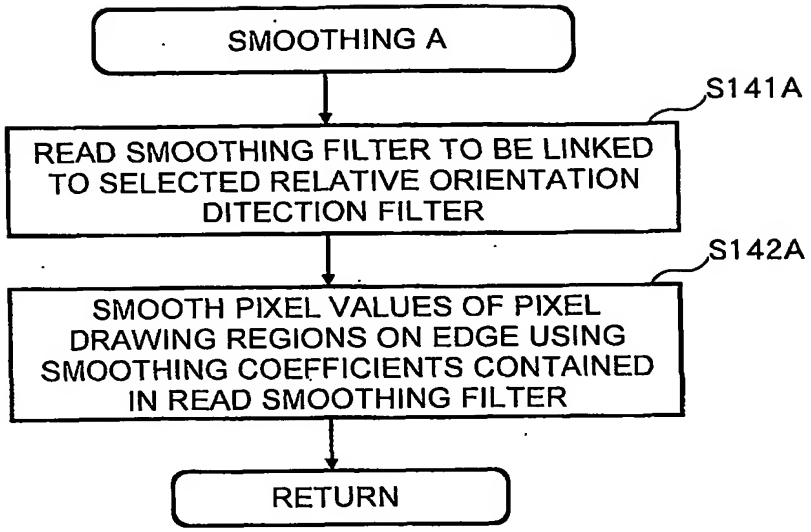

SMOOTHING A
S141A
READ SMOOTHING FILTER TO BE LINKED TO SELECTED RELATIVE ORIENTATION DITECTION FILTER
S142A
SMOOTH PIXEL VALUES OF PIXEL DRAWING REGIONS ON EDGE USING SMOOTHING COEFFICIENTS CONTAINED IN READ SMOOTHING FILTER
RETURN

FIG. 7

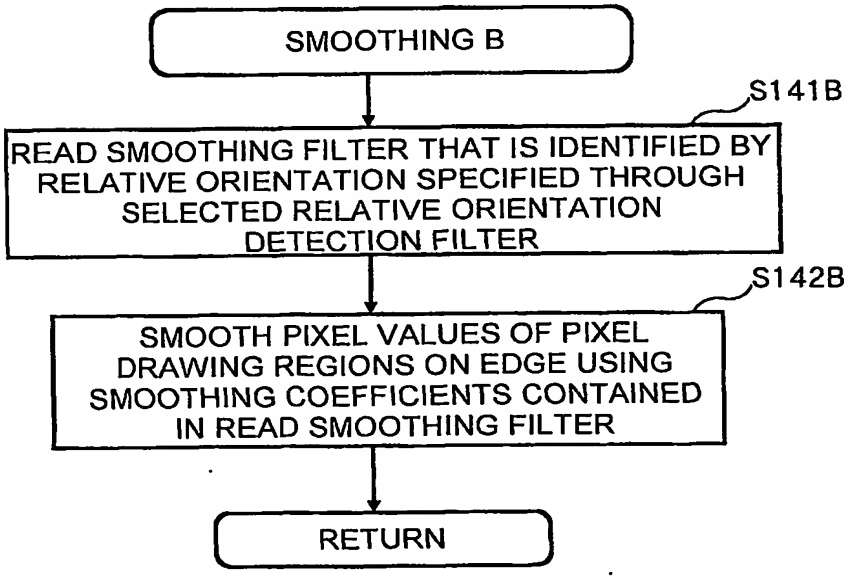

SMOOTHING B
S141B
READ SMOOTHING FILTER THAT IS IDENTIFIED BY RELATIVE ORIENTATION SPECIFIED THROUGH SELECTED RELATIVE ORIENTATION DETECTION FILTER
S142B
SMOOTH PIXEL VALUES OF PIXEL DRAWING REGIONS ON EDGE USING SMOOTHING COEFFICIENTS CONTAINED IN READ SMOOTHING FILTER
RETURN

FIG. 8

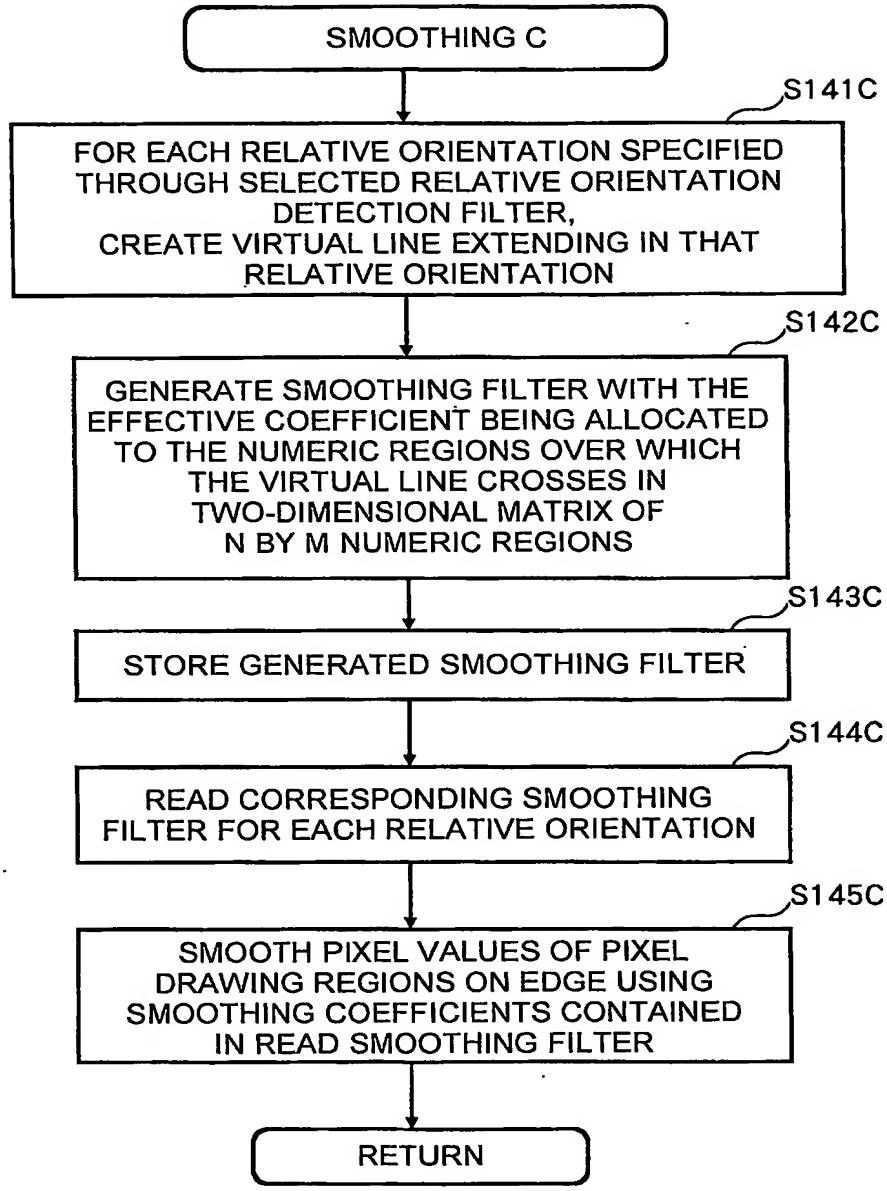

SMOOTHING C
S141C
FOR EACH RELATIVE ORIENTATION SPECIFIED THROUGH SELECTED RELATIVE ORIENTATION DETECTION FILTER, CREATE VIRTUAL LINE EXTENDING IN THAT RELATIVE ORIENTATION
S142C
GENERATE SMOOTHING FILTER WITH THE EFFECTIVE COEFFICIENT BEING ALLOCATED TO THE NUMERIC REGIONS OVER WHICH THE VIRTUAL LINE CROSSES IN TWO-DIMENSIONAL MATRIX OF N BY M NUMERIC REGIONS
S143C
STORE GENERATED SMOOTHING FILTER
S144C
READ CORRESPONDING SMOOTHING FILTER FOR EACH RELATIVE ORIENTATION
S145C
SMOOTH PIXEL VALUES OF PIXEL DRAWING REGIONS ON EDGE USING SMOOTHING COEFFICIENTS CONTAINED IN READ SMOOTHING FILTER
RETURN

FIG. 9

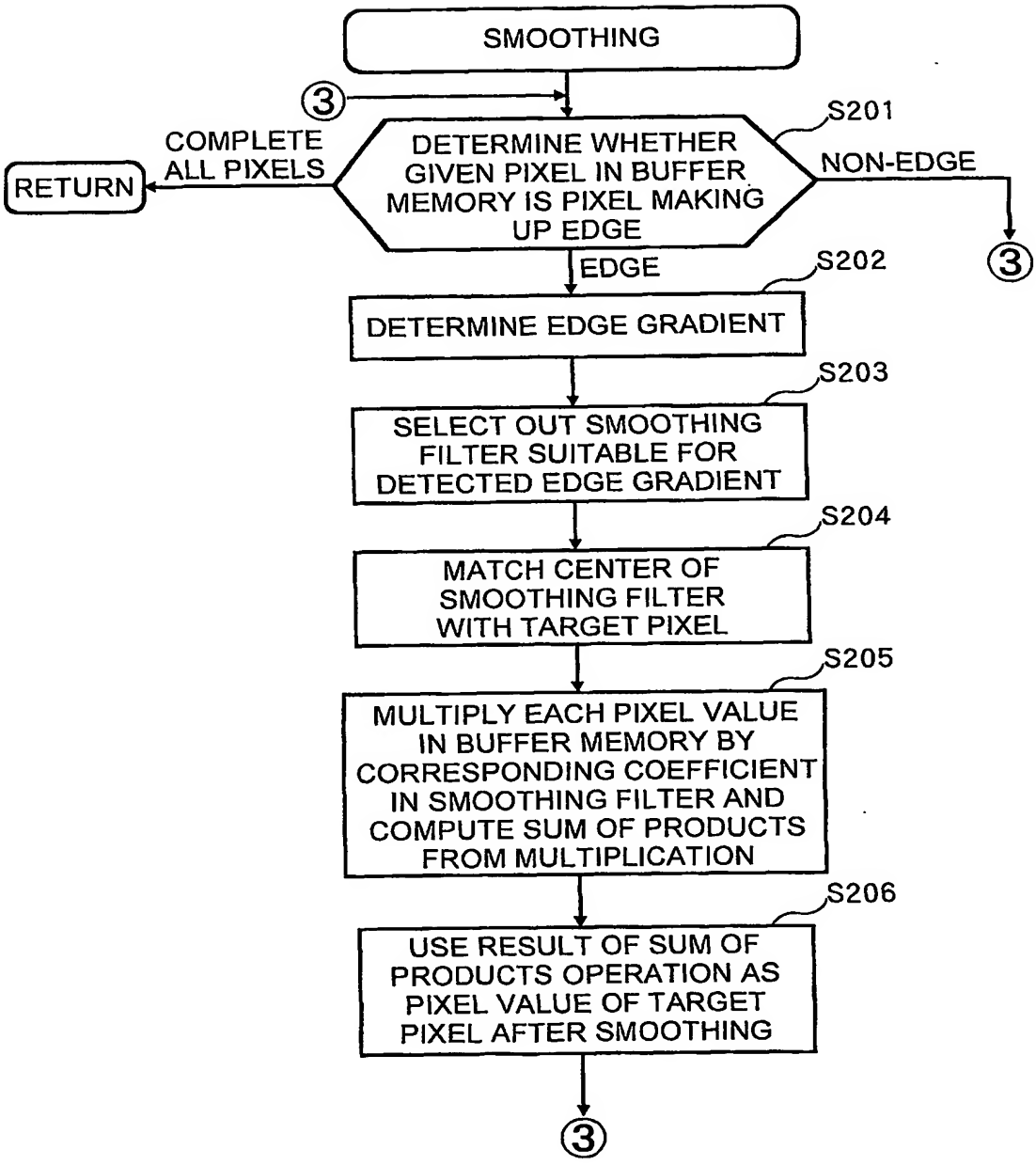

SMOOTHING
③
S201
DETERMINE WHETHER GIVEN PIXEL IN BUFFER MEMORY IS PIXEL MAKING UP EDGE
COMPLETE ALL PIXELS
RETURN
NON-EDGE
③
EDGE
S202
DETERMINE EDGE GRADIENT
S203
SELECT OUT SMOOTHING FILTER SUITABLE FOR DETECTED EDGE GRADIENT
S204
MATCH CENTER OF SMOOTHING FILTER WITH TARGET PIXEL
S205
MULTIPLY EACH PIXEL VALUE IN BUFFER MEMORY BY CORRESPONDING COEFFICIENT IN SMOOTHING FILTER AND COMPUTE SUM OF PRODUCTS FROM MULTIPLICATION
S206
USE RESULT OF SUM OF PRODUCTS OPERATION AS PIXEL VALUE OF TARGET PIXEL AFTER SMOOTHING
③

FIG. 10

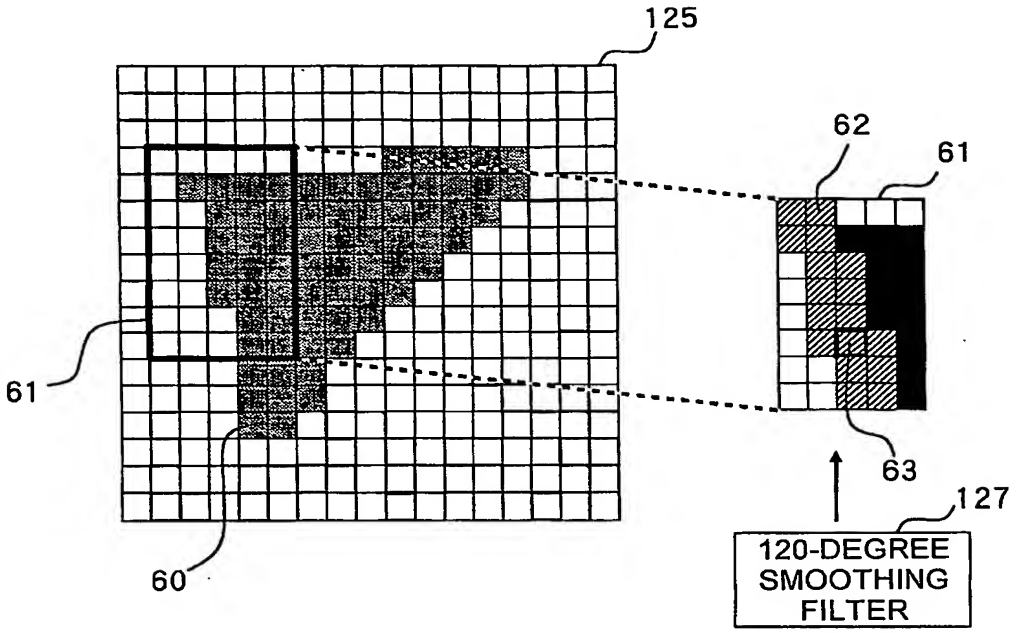


FIG. 11

0 × 0	0 × 0.1	1 × 0	1 × 0	1 × 0
0 × 0	0 × 0.15	1 × 0.15	1 × 0	1 × 0
0 × 0	0 × 0	1 × 0.2	1 × 0	1 × 0
0 × 0	0 × 0	0 × 0.15	1 × 0.15	1 × 0
0 × 0	0 × 0	0 × 0	1 × 0.1	1 × 0

$$1 \times 0.15 + 1 \times 0.2 + 1 \times 0.15 + 1 \times 0.1 = 0.6$$

FIG. 12

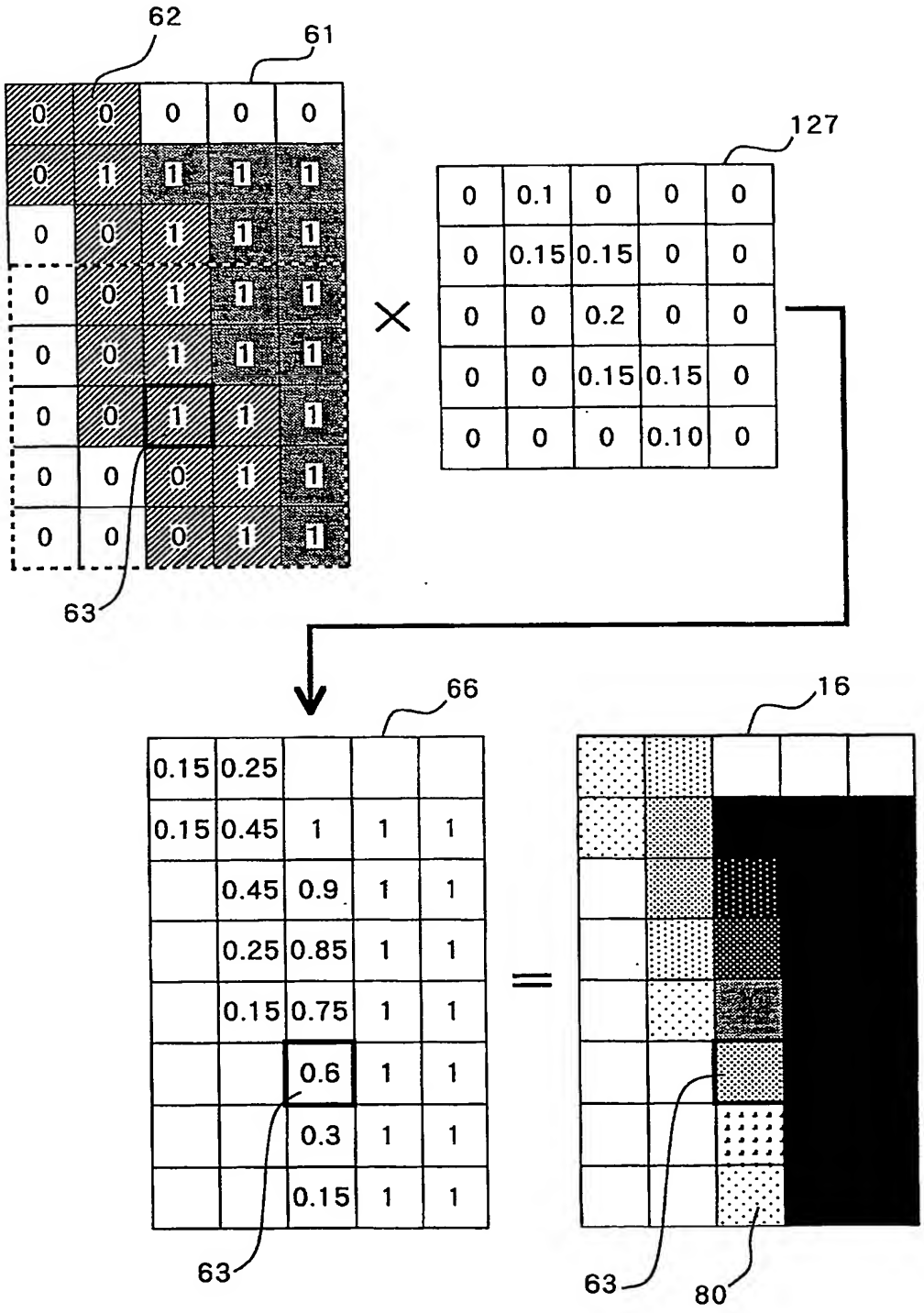


FIG. 13

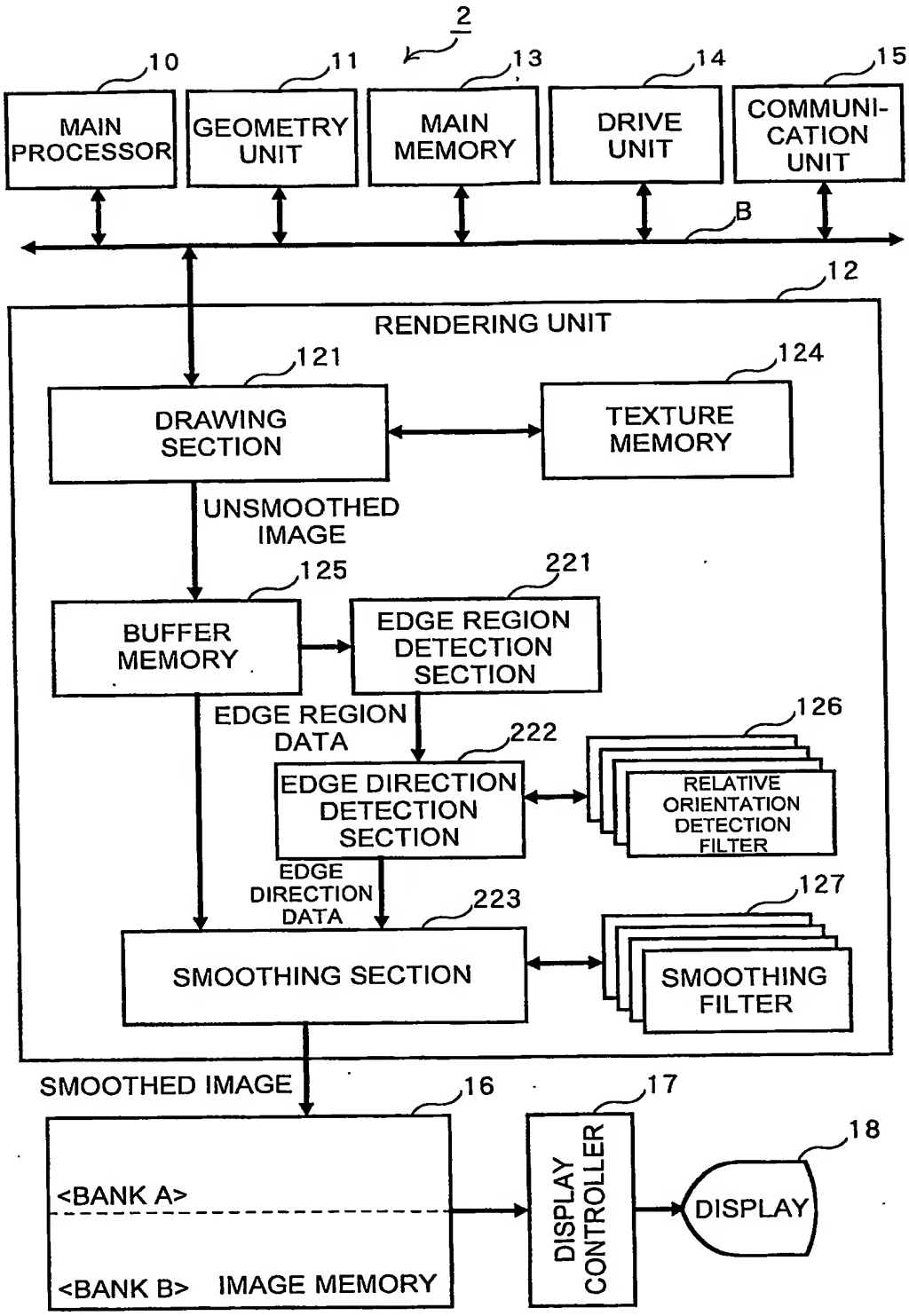

2
10
11
13
14
15
MAIN PROCESSOR
GEOMETRY UNIT
MAIN MEMORY
DRIVE UNIT
COMMUNI-CATION UNIT
B
12
RENDERING UNIT
121
124
DRAWING SECTION
TEXTURE MEMORY
UNSMOOTHED IMAGE
125
221
BUFFER MEMORY
EDGE REGION DETECTION SECTION
EDGE REGION DATA
222
126
EDGE DIRECTION DETECTION SECTION
RELATIVE ORIENTATION DETECTION FILTER
EDGE DIRECTION DATA
223
127
SMOOTHING SECTION
SMOOTHING FILTER
SMOOTHED IMAGE
16
17
18
<BANK A>
<BANK B> IMAGE MEMORY
DISPLAY CONTROLLER
DISPLAY

FIG. 14

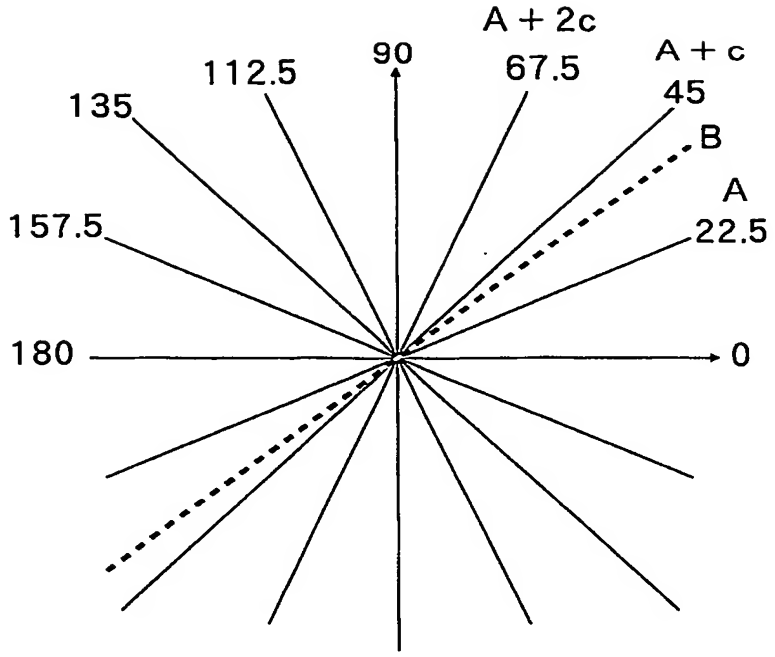

A + 2c
90
67.5
A + c
45
112.5
135
B
A
157.5
22.5
180
0

FIG. 15

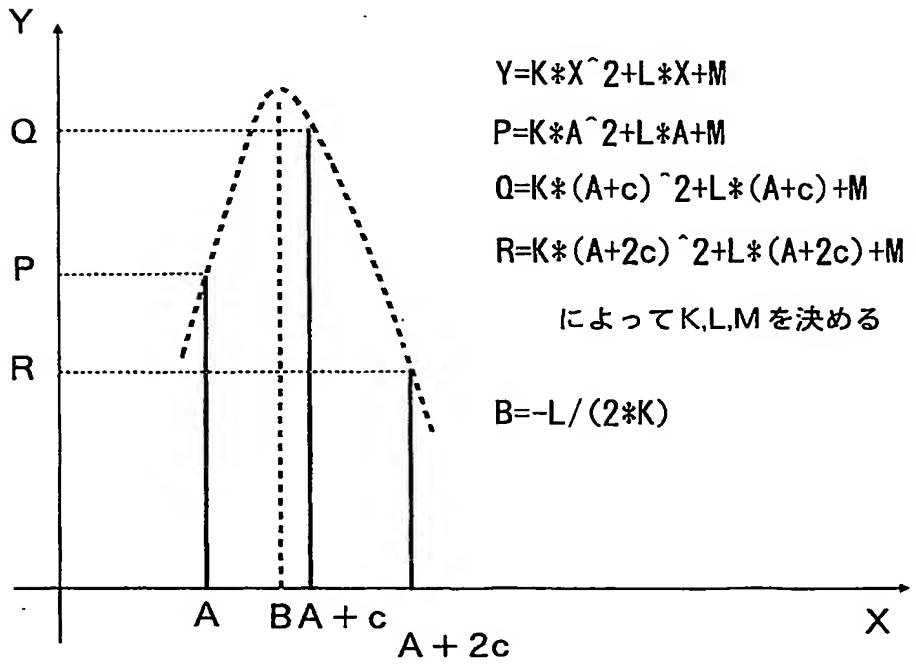
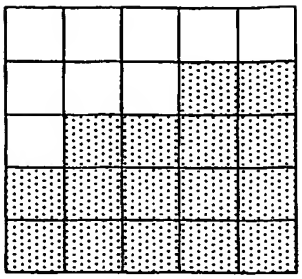

Y
Q
P
R
A
B
A + c
A + 2c
X
Y=K*X^2+L*X+M
P=K*A^2+L*A+M
Q=K*(A+c)^2+L*(A+c)+M
R=K*(A+2c)^2+L*(A+2c)+M
によってK,L,Mを決める
B=-L/(2*K)

FIG. 16

(a)



(b)

0	0	0	1	1
0	1	1	1	1
1	1	1	0	0
1	0	0	0	0
0	0	0	0	0

(c)

0	0	0	B	B
0	B	B	B	B
B	B	B	0	0
B	0	0	0	0
0	0	0	0	0

FIG. 17